

FINAL REPORT

PROJECT A-795

THE CONCEPT OF A BALANCED PRESSURE  
ACTUATED TOGGLE ACTION ELECTRICAL SWITCH

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Contract NAS8-11770

26 June 1964 to 25 October 1965

Prepared for  
George C. Marshall Space Flight Center  
National Aeronautics and Space Administration  
Huntsville, Alabama

1965



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## FOREWORD

This report was prepared by members of the staff of the Georgia Institute of Technology, Atlanta, Georgia, under Contract No. NAS8-11770 for the George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Huntsville, Alabama. The report presents results of an analytical and experimental study of mass balanced pressure actuated toggle action electrical switches. The work was administered under the technical direction of the Propulsion and Vehicle Engineering Laboratory with Mr. Darrell E. Melton acting as project manager. Mr. Melton's interest in the work, his helpful cooperation, and suggestions are deeply appreciated.

## ABSTRACT

This report presents the results of some experimental and analytical studies to attempt to design a mass balanced pressure actuated toggle action electrical switch for application in space vehicles. The results of a literature and industrial survey of the current state of the art of similar switches are given. From the survey it was apparent that a switch which met the desired requirements was not available from industrial sources. Therefore, an attempt was made to design a switch to meet the requirements of 100 g's, 1 1/2 percent actuation range, a vibration stable range of 10 to 2000 cps, and a temperature range of -200°F to +200°F.

The various types of prototype switches which were designed are described and the difficulties encountered in the designs are enumerated.



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## CHAPTER I

### THE CONCEPT OF A BALANCED SWITCH

In space vehicles there is a need for many pressure actuated electrical switches. A typical example of a requirement is a pressure sensing switch which, when a certain predetermined pressure is obtained, would almost instantaneously make an electrical contact to control a valve to vent a tank of fuel or oxidizer. As is readily evident perfectly insulated tanks for cryogenic fuels and oxidizers are not available and heat leaks cause cryogenic substances to vaporize and, consequently, build up pressure. The weight limitation of space vehicles necessitates that the tanks be made as light as possible. The light weight and temperature limitations, therefore, combine to make it imperative that the tanks have some protection from bursting due to the vaporization of the cryogenic substances. Of course, a converse situation may be found when the tank is being rapidly drained of fuel or oxidizer. In this case the system may have to be pressurized by helium or some other inert gas and, consequently, a valve must be opened when a predetermined minimum pressure is reached. Further considerations of space vehicles also indicate that the on-off-on range of the switch should be as small as possible in order not to vent valuable fuel and/or oxidizer when unnecessary. In other words it would be desirable to have a system which would maintain a precise pressure in the tank irrespective of heat load, pumping, and other factors. This could be approached if the on-off-on range of the switch is reduced to an absolute minimum taking into consideration the practical engineering problems introduced by accelerations, switch temperature, weight, vibration, and electrical requirements.

From more detailed information than that discussed above, actual desired requirements for one pressure actuated switch have been formulated. These are as follows:

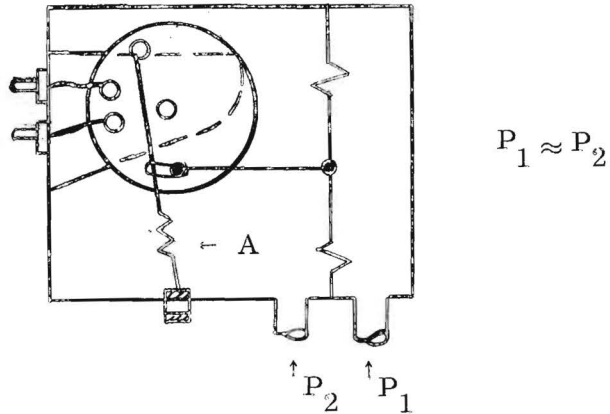
1. Maximum pressure for system 65 psia, minimum burst pressure 140 psia.
2. Double throw action, On at 65 psia - Off at 64 psia.
3. Operating medium - LOX vapor compatibility.
4. Operating temperature range,  $-200^{\circ}\text{F}$  to  $+200^{\circ}\text{F}$ .
5. Maximum weight - less than two pounds.
6. Electrical system - 3 ampere inductive load - 28 volts D. C.
7. Ability to withstand 100 g's - frequencies from 10 to 2,000 cps.

It is evident that the above requirements involve an extrapolation of existing capabilities and, therefore, necessitate the creation of new ideas and concepts. As a consequence the idea of a balanced switch as indicated in Figure 1 was conceived.

#### Literature Survey

It is customary and desirable before embarking on a new program to determine what is available in the literature. Therefore, a literature search was conducted to collect pertinent information on diaphragm actuated toggle switches. Over 200 manufacturers were contacted for general information on pressure and rotary switches. Over sixty percent responded and nineteen were supplied with more detailed information on the requirements. No switches were found in current production which met the requirements listed above.

Patents of the past five years were examined, in all classes and subclasses, which appeared to have potential application to the project. The patent search was curtailed at five years, because no patents were discovered which covered the features of interest to the project. The U. S. Patent Office was contacted for advice on subclasses of interest, and their advice guided the conduct of the search.



# 1st BALANCED TOGGLE SWITCH

- Probs: 1. "A" spring unsat.  
for vibrations
2.  $\Delta P$  operation only -  
as shown

Figure 1. Schematic Sketch of Balanced Toggle Actuated System

In Appendix I is given a list of industrial concerns which were contacted together with the letters requesting information. Copies of the brochures which have been accumulated on the project have been forwarded to Mr. Melton for possible future use in the conduct of research on pressure actuated switches. Near the end of the program a switch, which had just been put on the market, was discovered. According to the specifications of the manufacturer, this switch appeared to most closely satisfy the requirements as set forth heretofore. The manufacturer, SERVONIC INSTRUMENTS, INC. , a subsidiary of Gulton Industries, Incorporated, reported in response to a telephone inquiry, that

1. They could furnish the switch to give differential operation.
2. Could not use lower than  $-80^{\circ}\text{F}$  because of shift in calibration. The switch can be used at liquid nitrogen temperatures, however, a shift of +4 psi on a 50 psi unit could be expected.
3. The switch had coin silver contacts, was of a Belleville type diaphragm with pressure to snap through. Spring loading provides some adjustment with spring reacting against the Belleville.
4. Switch should be able to make at 65 psia and break at 63 psia, however, temperature drift precludes meeting the specifications outlined.

From all appearances the Servonic Model 91M sub-miniature pressure switch appears to most closely approach the specified requirements and these switches should be investigated more thoroughly by NASA.

## CHAPTER II

### THE PRINCIPLES OF THE BALANCED SWITCH

#### Acceleration Balancing

If a rigid body, for instance a space vehicle, is in motion in a straight line, the paths of all items or parts of the body are exactly alike, and the displacements of all particles during a given time are the same. Also the velocities of all particles at any instant are the same and their accelerations at any instant are the same. For this condition of translation, it is evident that it is possible to balance a beam, pivoted at the center, so that it will not move under changing velocity conditions. The basic principle of the balanced switch, therefore, is one where every pivoted body is identically balanced by an equal body pivoted to counteract the force any acceleration gives the first body. Schematically the principle is shown in Figure 2.

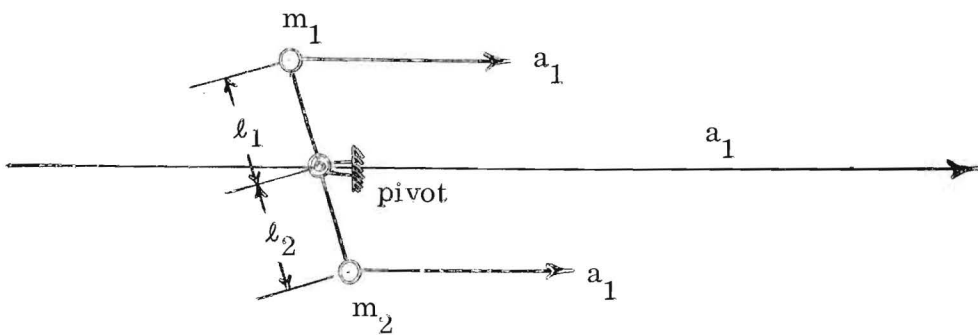


Figure 2. Balanced Masses in Translational Acceleration

If  $m_1$  equals  $m_2$ , and  $l_1$  equals  $l_2$ , and the acceleration is directional, as contrasted to rotational, then the torque applied around the pivot is zero

irrespective of the strength of the acceleration field and no movement will take place. If this pivot is connected to a toggle arrangement, then a switch action can be arranged which is essentially independent of linear accelerations. In this case the masses would be diaphragms or pistons connected to the system whose pressure is being controlled.

It should be emphasized that rotational accelerations would be more apt to influence a balanced switch since then the torques due to the two masses would act in the same direction. Therefore, the current switch concept is only applicable to linear accelerations.

Although the foregoing principle appears to be so simple as to be self evident, it has apparently not been applied or considered for the current switch application. Perhaps this is due to the fact that in addition to the balancing effect, other and perhaps more stringent restrictions are placed upon the design by the pressure range of only 1 psi for a pressure level of 65 psia. Normal rugged gauges are accurate to 1 percent of the full scale reading. Then if a burst pressure of 140 psia is required, it is apparent that a 2.8 psia span would be possible for a gauge, however, in order to actuate a toggle system additional force would be required and, consequently, the small pressure range desired would become impractical. In other words a spring or diaphragm which can withstand a large force with a relatively small increment of force to actuate the movement necessary for the toggle action is required.

In addition the wide range of temperature makes it mandatory that some compensating mechanism be provided to assure that the actuating pressure will not become a function of temperature. Also, the toggle mechanism must be rapid and balanced so that it is not influenced by acceleration, temperature, etc. It should make rapid and precise electrical contact to prevent arcing.

Basically the principles governing the design of the pressure switch are as follows:

1. Balance all masses against the effects of linear accelerations.
2. Compensate the mechanism against the effects of temperature changes.
3. Make the sensitivity of the switch sufficient to maintain a relatively small operating range at a high pressure level.
4. Size the components of the switch so that their critical frequencies are above those specified, 2000 cps.

In reference to item 4 above it should be pointed out that this imposes a drastic limitation on the size of the components of the switch. It was readily apparent after the first few designs were accomplished that miniaturization of the switch was absolutely necessary.



## CHAPTER III

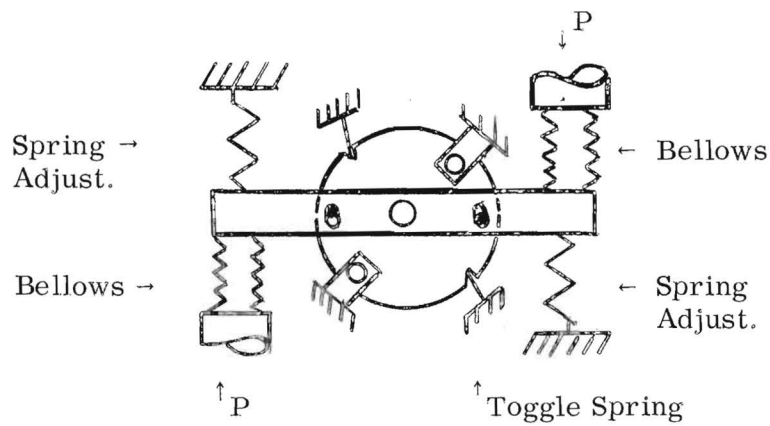
### EXPERIMENTAL DESIGNS

During the course of the research many and varied designs came under consideration. Of course these preliminary designs were not subjected to complete analyses until it was determined from cursory examinations that they had possibilities of meeting the requirements. The various designs considered are discussed in the following for historical reasons.

The first balanced toggle switch design was the one proposed prior to beginning this effort. It is shown schematically in Figure 1. Serious consideration of this design indicated that difficulties would be experienced in balancing the various springs required to give the toggle action and absolute pressure characteristics desired. The second design, shown schematically in Figure 3, minimized the balancing problems for the springs; however, it was decided that vibration still posed some difficulty. This design also made use of bellows which, when the 140 psi burst condition was imposed, could not readily give the on-off switching action at a 1 psi pressure differential.

Design number three, Figure 4, substituted limited pistons for the bellows and proposed to seal the pistons with a thin Teflon or other type membrane. The main springs in this design, since they were of a coil nature, were considered to be too difficult to balance under large gravitational forces and vibrations. Therefore, this design was abandoned.

The fourth design (see Figure 5) was substituted when it was determined that certain bourdon gauges had a sensitivity of 1/2 percent of full scale readings, which for a 100 psi gauge gave  $\pm 1/2$  psi accuracy. The absolute pressure setting



- Probs:
1. Springs unsat. for vibrations
  2. Bellows not sensitive enough
  3. Forces on springs make adjust. difficult

Figure 3. 2nd Balanced Toggle Switch

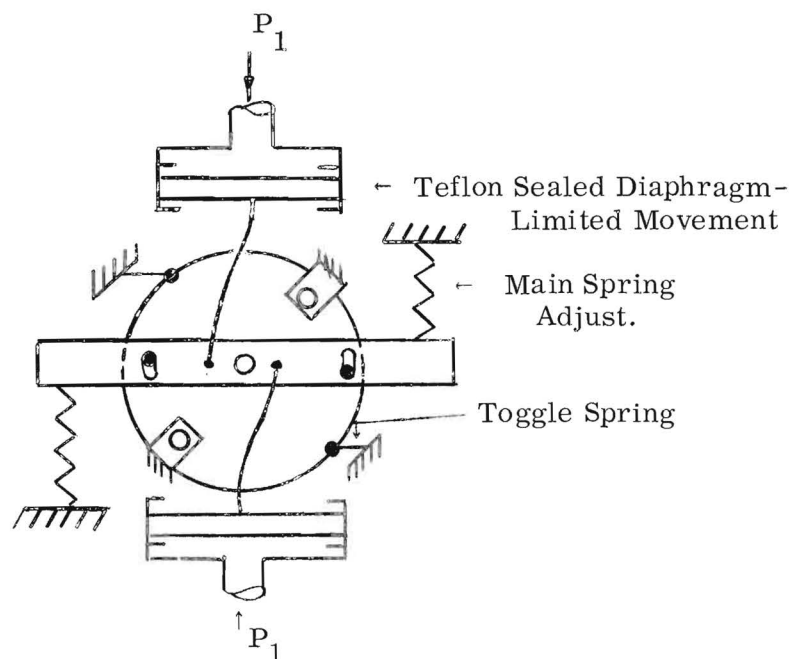


Figure 4. 3rd BALANCED TOGGLE SWITCH

- Probs: 1. Main springs unsat.  
for vibrations  
2. Switch details not  
resolved

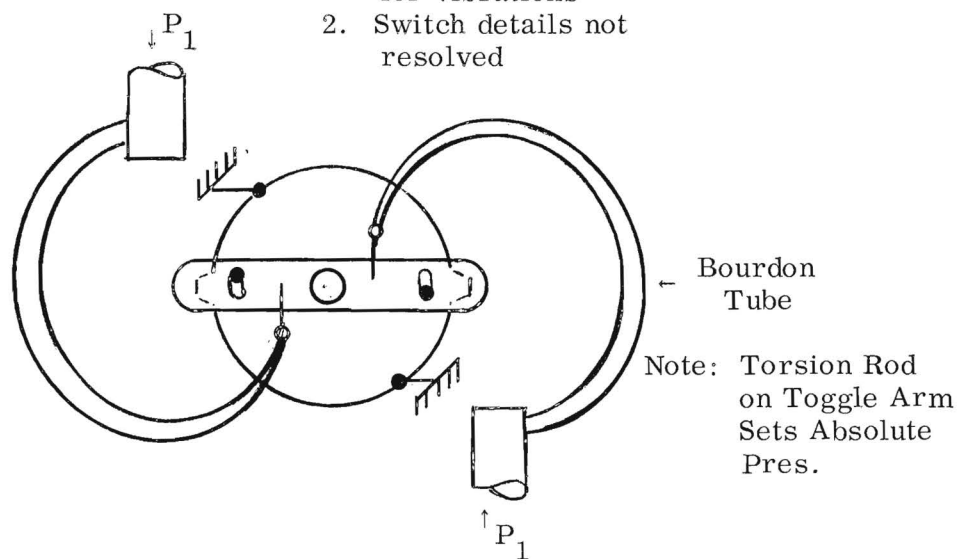


Figure 5. 4th BALANCED TOGGLE SWITCH

- Probs: 1. Sensitivity of bourdon tubes  
2. Switch details not resolved  
3. Torsion rod too long

device for this design was to be a torsion spring mounted on the axle of the toggle switch. An exploded view of the proposed switch is shown in Figure 6. This switch appeared to have the characteristics of a good design until the calculation for the torsion spring, which set the absolute pressure, was made. It was readily apparent that the length to diameter ratio of the torsion spring would give an excessively long rod. The equations that govern this calculation are given below:

#### Solid Round Bar

$$\phi = \frac{584 M_t \ell}{d^4 G}$$

$$\tau = \frac{16 M_t}{\pi d^3}$$

where  $\phi$  = wind-up angle, degrees

$\tau$  = shear stress, 140,000 psi for steel alloy spring

$M_t$  = applied torque moment

$d$  = bar diameter inches

$\ell$  = active length of spring

$G$  = modulus of rigidity,  $11.5 \times 10^6$  psi for steel alloy springs

In addition to excessive length, it was also apparent that difficulty would be encountered in compensating the torsion rod for temperature changes.

Figure 7 shows a schematic drawing of the 5th design considered. In this design a balanced sealed piston arrangement was used. It should be noted from the figure that the Teflon diaphragm is enclosed in a chamber and, consequently, does not have to withstand the total pressure of the system. In other words it will deform to the walls under pressure and will seal the small cracks between the pistons and cylinders. One difficulty which was anticipated for this design was pinching of the diaphragm. The movement was, consequently, limited

# DETAILS OF 4th DESIGN

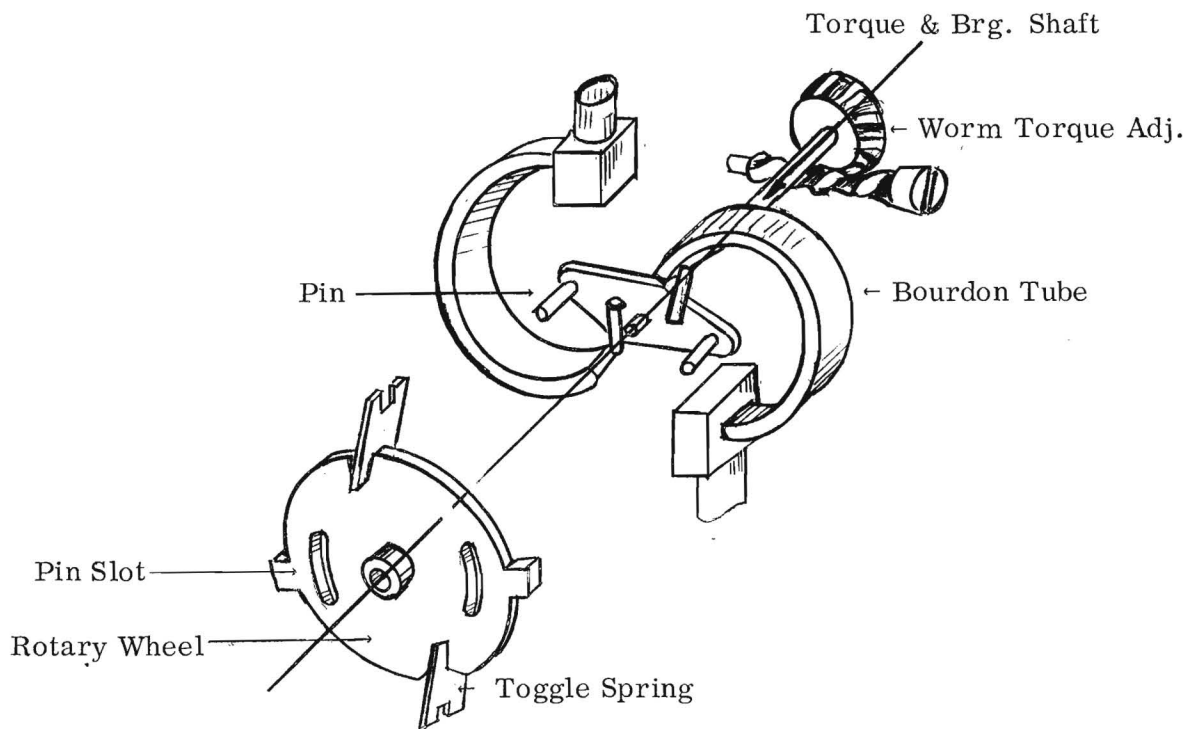


Figure 6. EXPLODED VIEW OF MAIN ELEMENTS  
OF 4th BALANCED TOGGLE SWITCH

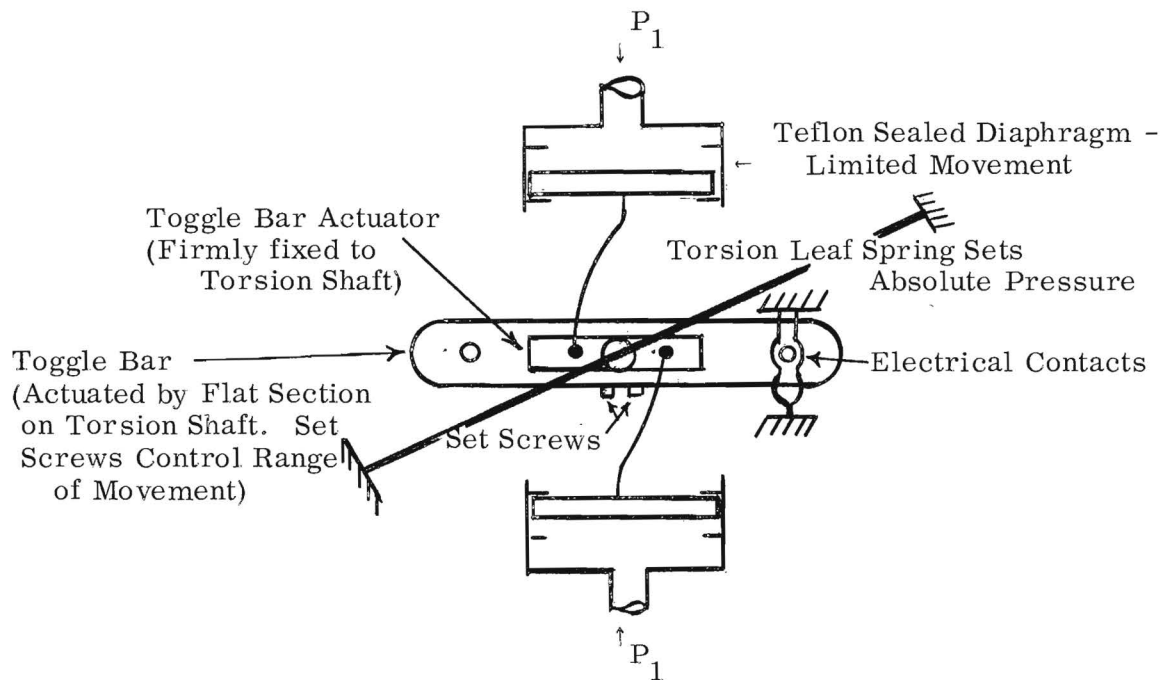


Figure 7. 5th BALANCED TOGGLE SWITCH

- Probs: 1. Sensitivity of switch  
 2. Teflon diaphragm operation

to approximately 1/8 inch and with this small displacement it was felt that pinching would be minimized. Teflon was proposed because it should be inert to oxygen and satisfactory for the temperature range under consideration. For this gauge, it was intended that the pistons would operate between well defined limits. This limited action was to move a toggle arm on which the electrical contacts were mounted. The toggle action being controlled by hourglass like contacts as indicated in Figure 7. One side of the hourglass contact was to be a common electrical lead whether the contact was in the upper or lower segment of the spring contacts. The other side was to be connected to either an upper position 1 or a lower position 2, which were separated electrically. The spring contact was to be adjustable so that it contributed slightly to the force on the movable toggle or switch arm. The two forces on the toggle arm, the pressures on the pistons and the spring tension, were then to determine the operating characteristics of the switch. Prototype hourglass contacts were fabricated and tested and they proved to be unsatisfactory because of the friction between the contacts and the switch arm contact. The main difficulty, however, with Design No. 5 was the leaf spring which was to set the absolute pressure for the system. This spring to provide the necessary sensitivity would have to be several feet long. Consequently, it was necessary to go to a torsion wound spring as indicated in Design No. 6, which is shown schematically in Figure 8. This design had ball-detent actuators for the toggle action and in order to check whether or not these would be satisfactory, it was decided to build a prototype switch utilizing this design. Figure 9 shows a front view of the switch, while Figure 10 shows the side view. In Figure 11 is an exploded view showing the switch disassembled. This switch as constituted was not acceptable since it required a force of approximately 3 psi to actuate the toggle mechanism. Also the bellows, which had extremely

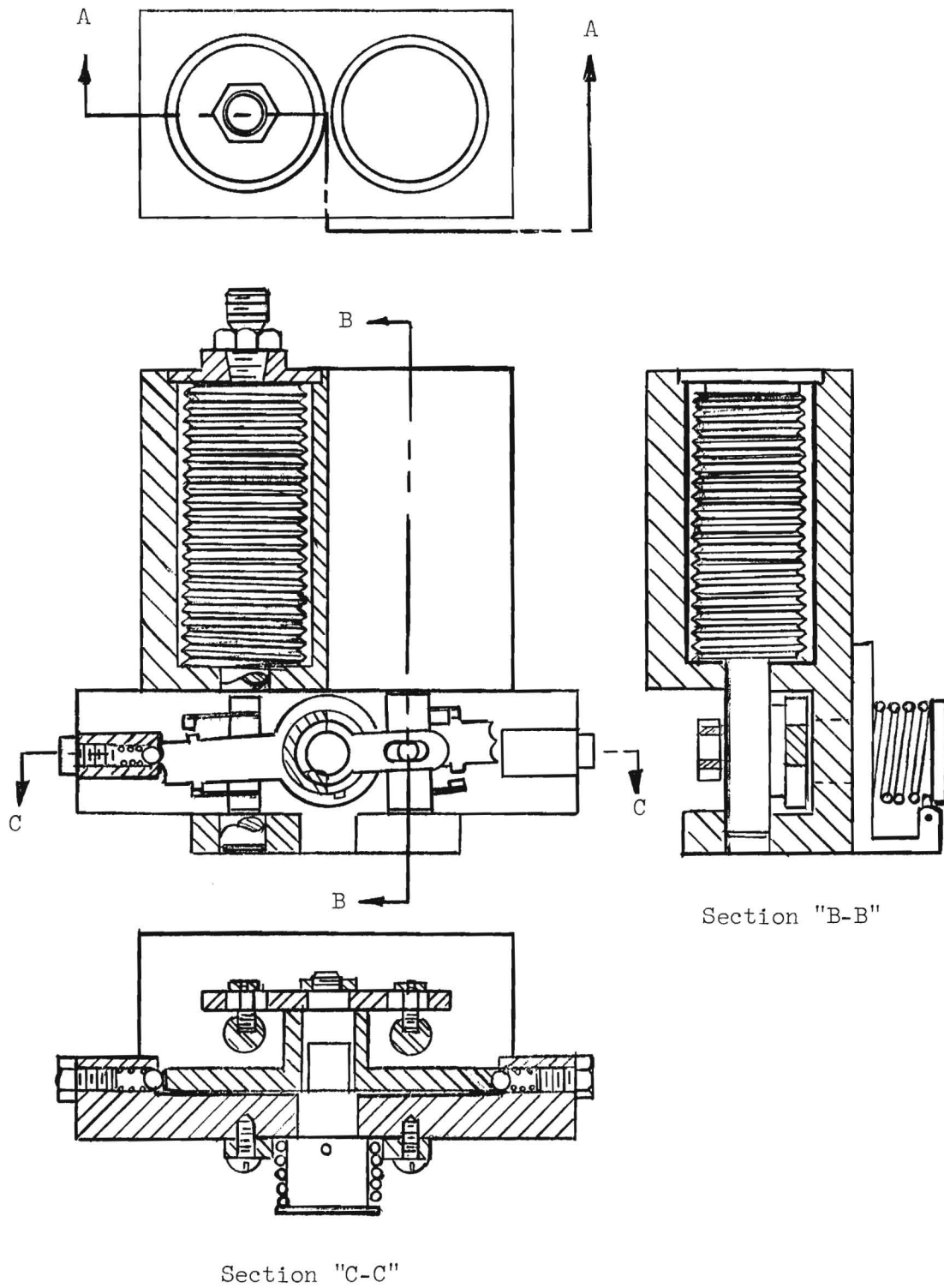


Figure 8. Design No. 6 - Balanced Toggle Switch.



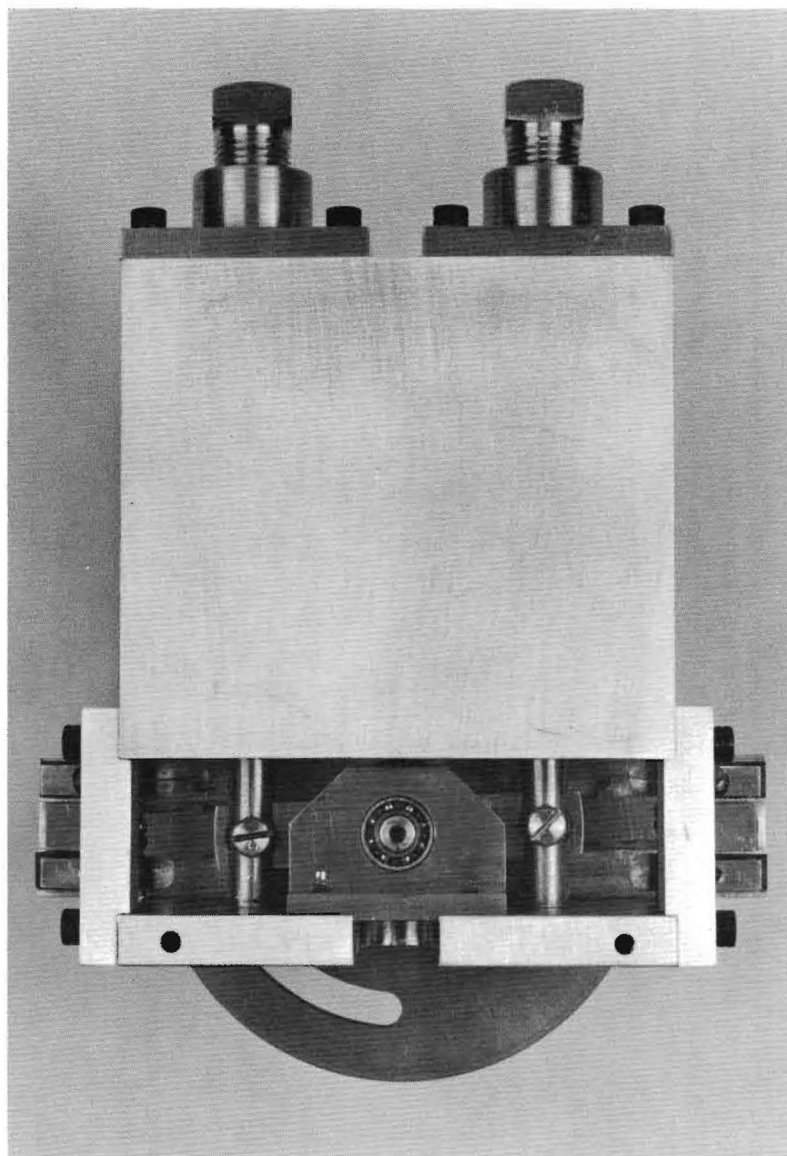


Figure 9. Design No. 6 (Front View).

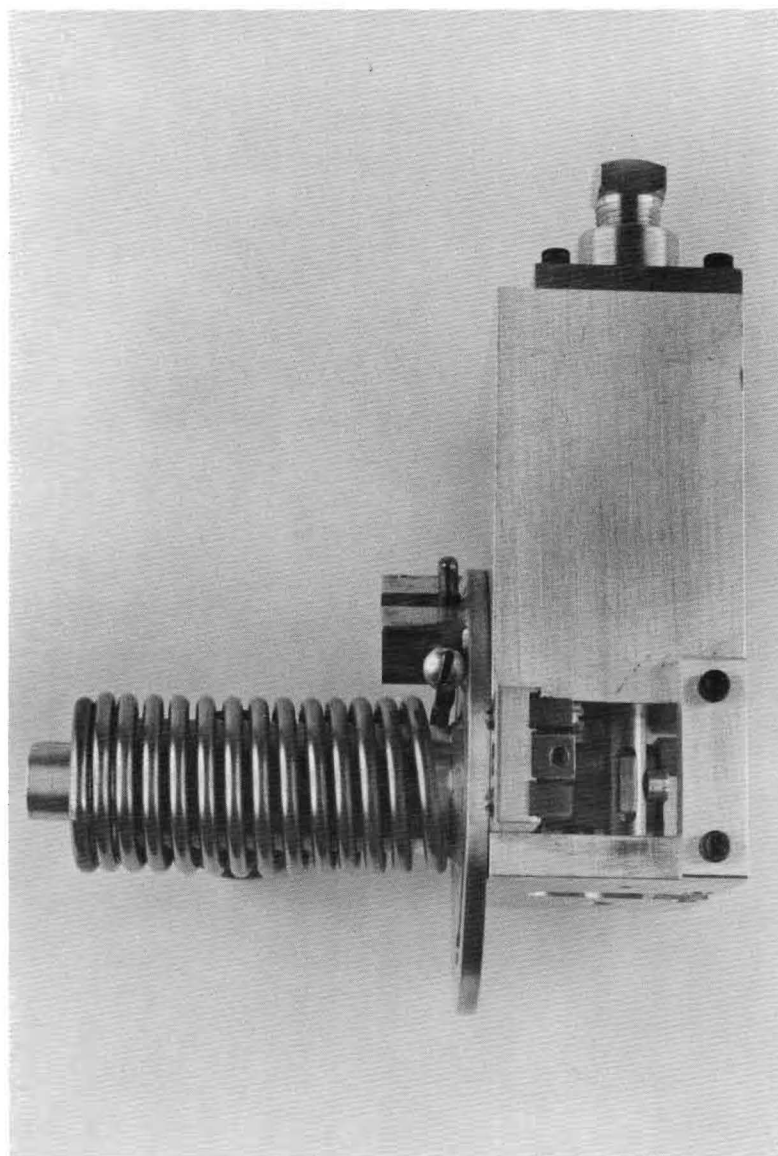


Figure 10. Design No. 6 (Side View).

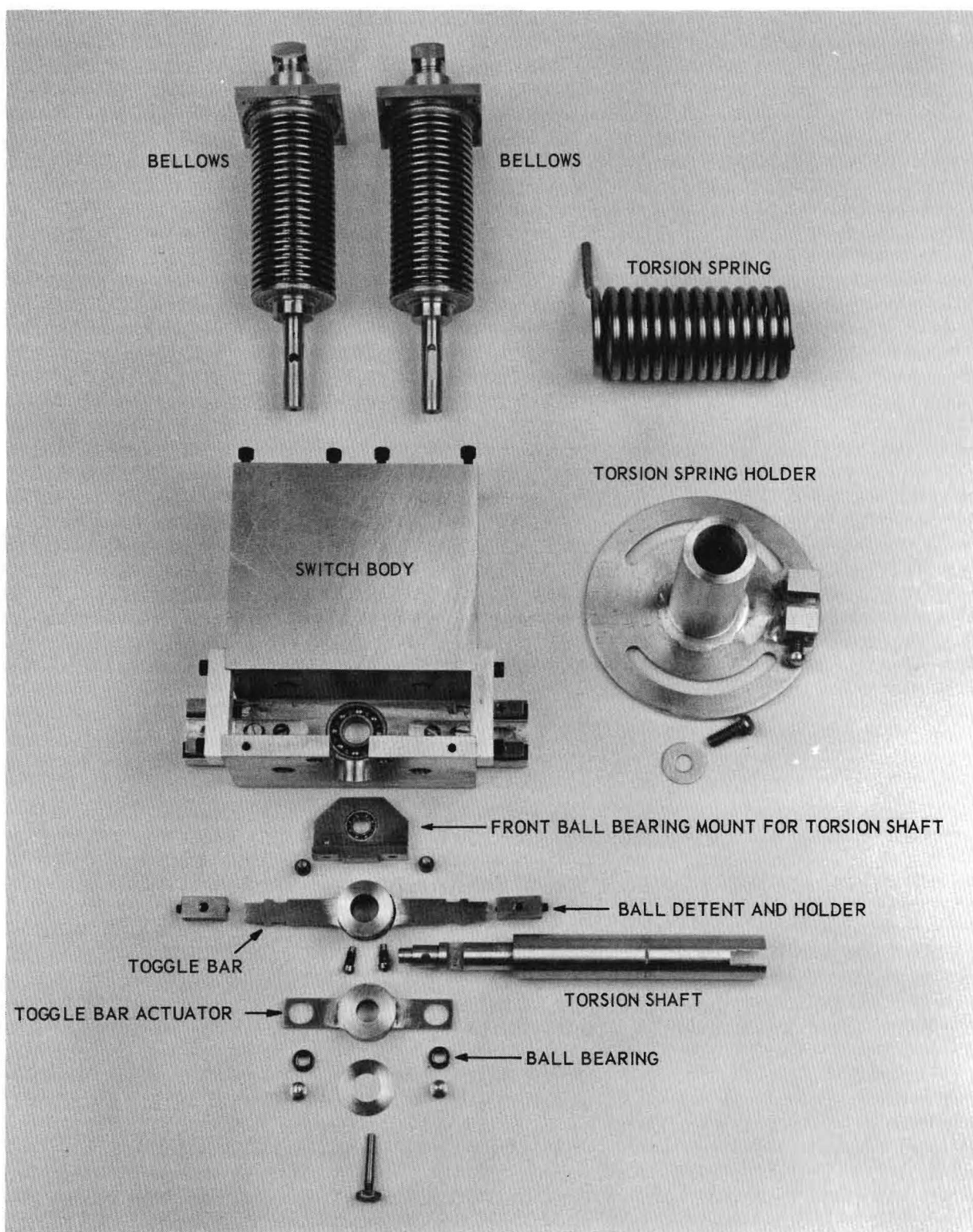


Figure 11. Design No. 6 (Disassembled).

low spring constants and which were used to form the pressure sensing pistons, made it evident that the switch would not be acceptable from a vibrational standpoint. In addition, the torsion spring which was used was adversely affected by vibrational forces at high g loadings. The switch, however, did indicate that the ball detent system for controlling the toggle action was as unsatisfactory as the hourglass contact system. This fact led to the consideration of a toggle action which is described in the next chapter.

As indicated in Figure 11 ball bearings were used on the pivot arms, etc., in Design No. 6 in order to reduce the forces required to actuate the shaft when the main torsion spring shown in the figure was set to maintain a switch pressure level up to 65 psia. In the exploded view of the switch, the action of the mechanism can be traced. When the right bellows is evacuated in the assembled switch and the pressure to be controlled is permitted to enter the left bellows, a force on the toggle bar actuator is generated to push it to the down position on the left side of the switch. This force is counterbalanced by the torsion spring acting on the toggle bar actuator through the torsion shaft. After the toggle bar actuator shaft moves a few degrees it trips the toggle bar which makes the necessary electrical contacts. The toggle bar, as indicated before, is controlled by ball detents which act in grooves on the ends of the toggle bar. Four ball bearings are utilized in this mechanism: two to support the torsion shaft; and, two are in the toggle bar actuator itself where the bellows' shafts connect to the toggle bar actuator.

The double bellows arrangement makes the switch insensitive to outside atmospheric pressure changes. Regardless of the outer pressure, it cannot cause a movement of the toggle bar actuator since it is balanced by the two bellows. This arrangement should also make the switch, at least from the bellows effect, insensitive to temperature changes, since a change in one

bellows should be counterbalanced by the other. It was realized quite early that the torsion spring would be difficult to compensate for temperature changes; however, it was anticipated that this could be accomplished by making a composite spring with one half winding up and the other half unwinding to create the pressure level desired.

Preliminary experimental testing of the Prototype switch of Design No. 6 indicated the following:

1. With the main torsion spring unconnected,  
1/2 psi would toggle switch
2. With torsion movement to tighten torsion spring  
(winding spring)  
On - 46 psig              Off - 39.5 psig
3. With torsion movement to loosen spring  
(unwinding spring)  
On - 31 psig              Off - 28 psig  
39                              36  
56                              52.5
4. With torsion movement to loosen spring and with  
precise adjustment of pivots and detents:  
On - 54.5 psig              Off - 51.5 psig  
65                              62.2

From the above it was evident that the prototype switch did not approach the desired 1 psi on-off operation. Examination of the switch indicated that the reason for the large on-off range was due to the following:

1. The ball detents required too much force for proper action. (By properly shaping the grooves in the ends of the toggle bar, this force may have been reduced; however, it was decided that a much better design would result if a more rapid action were incorporated into the toggle action.) (See the next Chapter.)
2. The torsion spring was not made of the proper material and designed for too small a movement for the force available. Also the spring should have been annealed to eliminate the stress from winding. This caused the variation in the two cases of winding and unwinding as indicated above.

Of course, it was realized that the bellows would not be satisfactory from a vibrational standpoint. In addition, the torsional spring was too large to have a fundamental vibrational frequency above 2000 cps.

## CHAPTER IV

### ANALYTICAL CONSIDERATIONS

With the experience obtained from the foregoing designs of switches, it was decided to attempt to design a switch, based upon the main features of the preceding designs, which would meet the required conditions. Because the main problems appeared to be of a vibrational nature, it was decided to start with the vibrational limitation rather than with an initial pressure differential for actuating the mechanism. Briefly the switch design will consider the following:

1. Vibrational characteristics
2. Balanced pressure sensing element
3. Toggle characteristics

#### Vibrational Characteristics

The main spring, which is to set the level of operation of the pressure sensing device, is assumed to be a torsion spring. Any spring such as this which is subjected to a rapid variation in load will experience dynamic effects which can increase the stress in the spring appreciably. If the variation in loading occurs at a frequency which corresponds to the natural frequencies of the spring, then particularly severe effects can occur. Although all of the harmonics of the spring's natural frequency can influence the effects, it is usually the lowest natural frequency which is most important. Since the spring under consideration (Design No. 6) is helical wound and slightly compressed, it is interesting to determine its lowest natural frequency where the first mode of vibration will consist of a vibratory motion of the middle part of the spring with the ends remaining fixed. Schematically the spring is shown in the figure below.

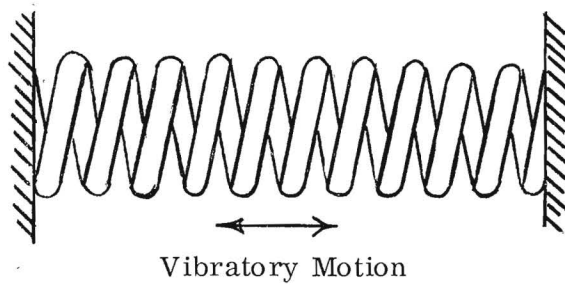


Figure 12. Helical Spring with Fixed Ends

Natural Frequencies: The lowest natural frequency for the spring indicated in Figure 12 is given by the following formula:

$$f_n = \frac{2d}{\pi D^2 n} \sqrt{\frac{G g}{32 \gamma}}^*$$

where  $n$  = number of active coils

$d$  = diameter of spring wire, inches

$D$  = diameter of coil, inches

$g$  = acceleration of gravity

$G$  = shear modulus  $11.5 \times 10^6$  psi for steel springs

$\gamma$  = density  $0.285 \text{ lbs/in}^3$  for steel

Simplifying the above and considering steel springs gives

$$f_n = \frac{14,100 d}{D^2 n}$$

It is evident that frequencies in the higher modes of vibration are 2, 3, 4, etc., times the fundamental frequency given above.

\* Mechanical Springs, A. M. Wahl, McGraw-Hill Book Co., Inc., Sec. Ed., 1963.

Considering 2,000 cps to be the lowest acceptable frequency then

$$2,000 = \frac{14,100 d}{D^2 n}$$

and

$$D^2 n = 7.05 d$$

With a  $D/d \approx 10$

$$D n = 0.705$$

and if  $D = 1/4$

$$n = 2.82 \text{ coils}$$

From which the length of the spring can be calculated

$$\begin{aligned} \ell &= \pi D n \\ &= \pi(1/4) 2.82 \\ &= 2.22 \text{ inches} \end{aligned}$$

Transverse Frequencies: If the helical spring is confined at both ends the natural frequencies for transverse vibrations are given in Figure 13. From the figure it is evident that for the above spring for an  $\ell/D = 2.22 / 1/4 = 8.88$

$$\frac{f_t}{f_n} \approx 0.40$$

and

$$f_t = 800 \text{ cps}$$

for a longitudinal frequency of 2,000 cps.

If, however,  $f_t$  is set at 2,000 cps, then

$$f_n = 5,000 \text{ cps.}$$



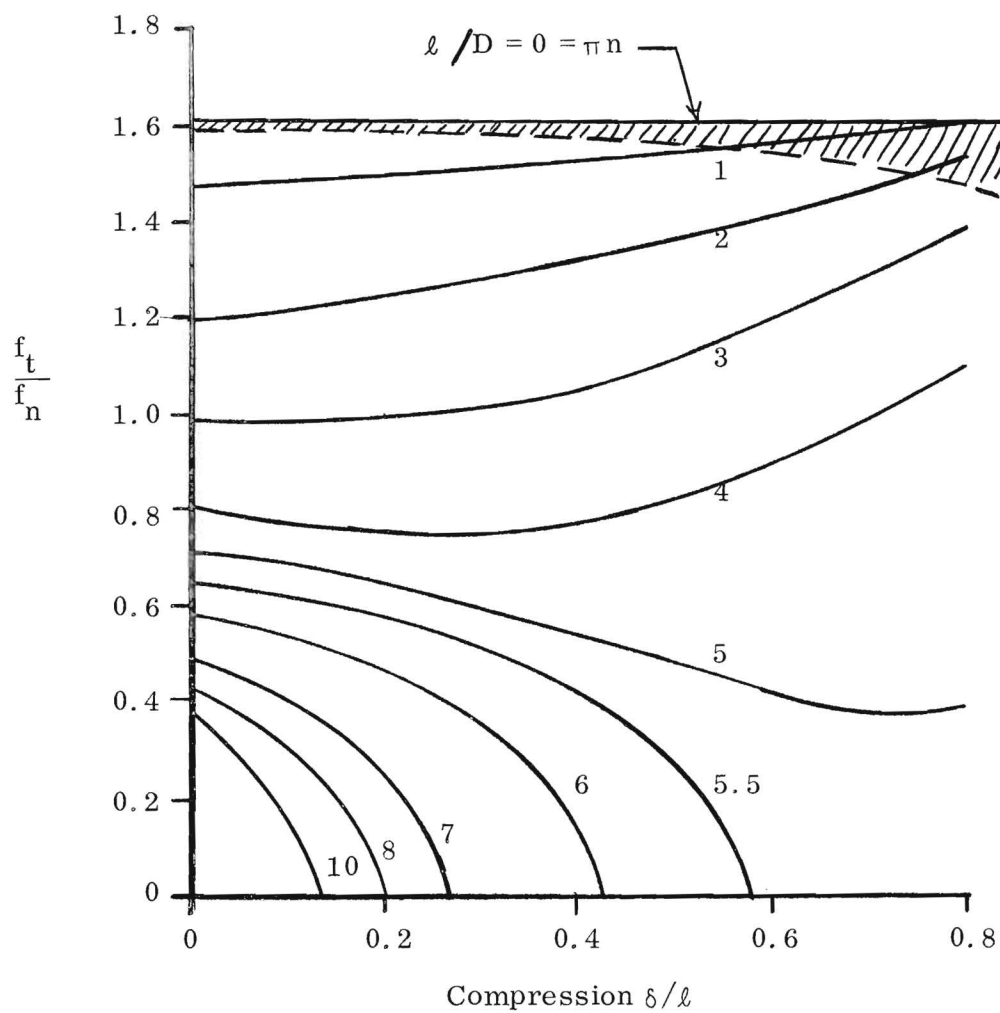


Figure 13. Ratio of Lowest Natural Frequency  $f_t$  for Transverse Vibration to Lowest Natural Frequency  $f_n$  for Longitudinal Vibration in Compressed Helical Spring

And for a natural longitudinal frequency of 5,000 cps

$$D^2 n = \frac{14,100}{5,000} d = 2.82 d .$$

Considering  $D/d$  to be 10

$$D n = 0.282$$

Now if  $\pi n \approx \ell/D \approx 10$ ,  $n = \frac{10}{\pi}$

and

$$\frac{D (10)}{\pi} = 0.282$$

Therefore,

$$D = 0.0886$$

and

$$d = 0.00886 \text{ inches.}$$

The above indicates that if the transverse natural frequency of the spring is limited to 2,000 cps, the wire size would be only 0.00886 inches. This indicates a severe limitation on the size of the torsion spring.

Assuming that only longitudinal vibrations are present, it is interesting to consider the spring length requirements to give the sensitivity desired. For a torsion spring the following equations apply.

#### Round Wire Helical Torsion Spring

$$\sigma = k \frac{10.2 M}{d^3} *$$

where  $\sigma$  = stress in wire, psi

$M$  = moment acting, inch-pounds

$d$  = diameter of spring wire, inches

$k$  = a constant depending on the  $D/d$  ratio for the spring, for a  $D/d$  of 10,  $k$  equals 1.08

Using a  $D/d$  of 10 and a spring coil diameter  $\bar{D}$  equal to 1/4 inch (this limitation is due to vibration) the above equation becomes

$$\sigma = \frac{1.08 (10.2) M}{(0.025)^3}$$

The maximum stress for music spring wire in the 0.025 inch diameter range is approximately 260,000 psi; therefore,

$$260,000 = 1.08 (10.2) M / (0.025)^3$$

and  $M = 0.368$  inch pounds

The deflection in degrees for a torsion helical spring is given by

$$\varphi = \frac{3670 M n D}{E d^4}$$

where  $E$  is the modulus of elasticity, which for steel is 30,000,000 psi.

Consequently,

$$\varphi = 221 M$$

If the spring is stressed to its limit ( $M = 0.368$  inch pounds), then

$$\varphi = 81.5^\circ$$

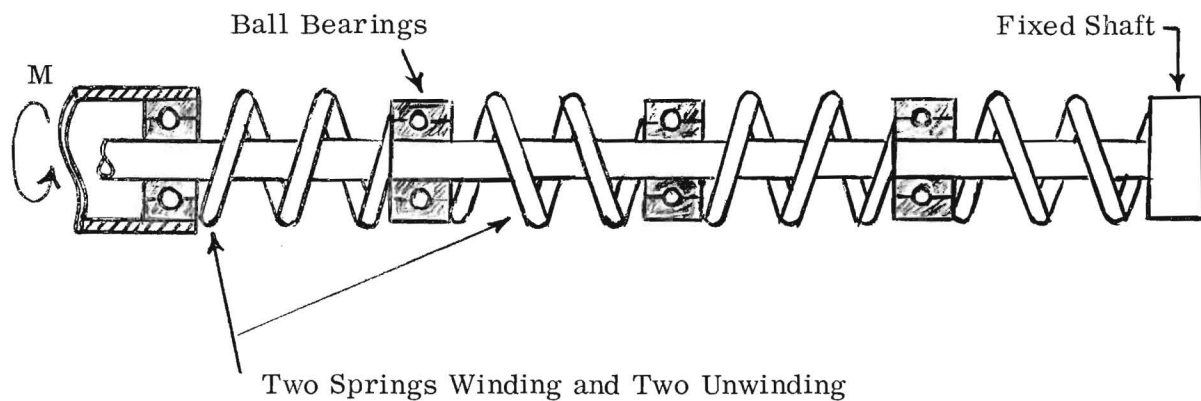
Therefore, the movement of the spring (assuming 1/2 psi is available to actuate the switch) is

$$\frac{m}{M} \approx \frac{1/2}{65} = \frac{\varphi_1}{81.5}$$

$$\varphi_1 = 0.626^\circ$$

Consequently, a spring resisting a moment due to a force of 65 psi would move only  $0.626^\circ$  if an additional force of 1/2 psi were imposed.

The movement of only  $0.626^\circ$  is too small to activate a toggle mechanism, therefore, it is necessary to lengthen the spring appreciably. A movement of  $2.5^\circ$  appears to be satisfactory and, consequently, if four springs were used this movement could be obtained. A question now arises as to how four springs could be used without unduly influencing the vibrational characteristics. A unique solution to this problem was determined and is shown in Figure 14.



Note: All springs attached to outer races of ball bearings and fixed shaft.

Figure 14. Method of Arranging Helical Torsion Springs to Increase Effective Length and to Compensate for Temperature Changes

#### Piston Diameter

To determine the size of the piston required, consider the moment acting on the helical torsion spring arm. This moment is  $M = 0.365$  inch-pounds. Also consider the pressure,  $P$ , in the system to be 65 psia and that the piston diameter,  $x$ , is identically equal to the moment arm,  $z$ . Then

$$A P z = 0.365$$

$$\frac{\pi x^2}{4} P_z = 0.365$$

$$\frac{\pi x^3}{4} 65 = 0.365$$

$$x^3 = 0.00715$$

or

$$x = 0.2 \text{ inches}$$

This diameter of 0.2 inches appears to be reasonable for the piston.

### Toggle Mechanism

The toggle mechanism to be used was finally determined to be as indicated in Figure 15.

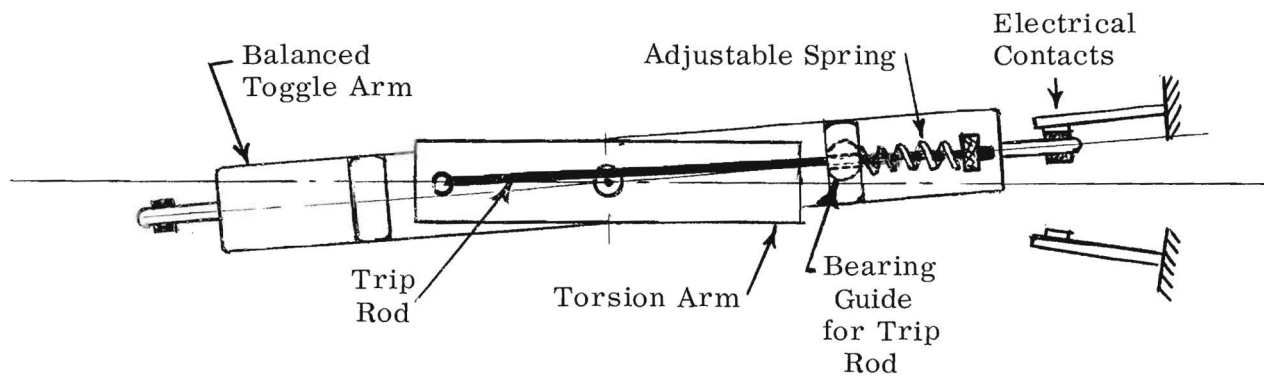


Figure 15. Schematic Diagram of Toggle Mechanism

Since the pistons, torsion spring, etc. , must for vibrational reasons be small, it is apparent that the toggle mechanism must also be small. This fact requires clockwork precision in manufacture, jewel bearings, etc.

## Overall Pressure Switch Design Considerations

A pressure switch may be made using balanced sealed pistons, a modified helical torsion spring, and a toggle mechanism. However, vibrational requirements indicate that an acceptable switch would have extremely small components and require a very expensive and accurate manufacturing process. The miniaturization appears to be so formidable that the current effort was curtailed.

Figure 14 indicates a method by which the effect of vibration on a long torsion spring may be minimized. In this design the natural longitudinal frequency of each individual spring is the limiting value. Also, the means of temperature compensation of the torsion spring (two springs winding and the other two unwinding as the torque is applied) appears satisfactory. Because a temperature change will either unwind or wind up a spring, two similar springs undergoing the same temperature change will both unwind or wind a given number of degrees. If the springs are in series as shown in Figure 14, the unwinding action of one will oppose that of the next so no movement will take place.

The analytical calculations are somewhat limited due to the many variables involved and the unfavorable limitations imposed by the frequency range. It may be possible to find a better combination of factors; however, since the effects of rotational accelerations, vibrations, etc., indicate the possibility of severe limitations in the design, no further effort was expended in an attempt to further the work.

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

As a result of the work accomplished and the experience obtained, it is evident that the specifications put forth for the desired pressure actuated toggle acting switch are much too severe for the current state of the art. The following conclusions have been arrived at from the work:

1. The idea of dynamic balancing the component parts of mechanisms for space vehicles is a good one. It is important, however, to realize that rotational or curvilinear accelerations of the space vehicle may make the balanced members more sensitive to these effects.
2. The frequency spectrum, 10 to 2000 cps, of necessity makes the components of the pressure switch extremely small and this would necessitate miniaturization. While miniaturization is desirable, it is questionable if it is possible to go to the limit required to satisfy the requirements for the pressure switch.
3. The sensitivity required, actuation between 1 psi at a level of 65 psi, requires the springs or torsion bars, which set the pressure level, to be relatively long. This fact introduces vibrational and frictional problems which may make validity of the calculations for real situations questionable.
4. A unique switch has been built which, although not satisfactory, incorporates principles which have not previously appeared in practice.
5. A literature survey of the various pressure switches which are on the market indicated one which utilizes a snap action diaphragm which is miniaturized and which may, with further development, satisfy to a better degree the requirements for a pressure switch for space vehicle application.

Based upon the work and the experience gained, it is recommended that:

1. An investigation of the SERVONIC Model 91M switch be conducted to determine if it with further development could approach more closely the requirements of NASA for a space vehicle pressure switch.
2. Further consideration be given to balancing various components of switches to minimize the effects of acceleration.

APPENDIX  
SURVEY OF PRESSURE SWITCHES FOR POSSIBLE  
APPLICATION TO SPACE VEHICLES



## APPENDIX

### SURVEY OF PRESSURE SWITCHES FOR POSSIBLE APPLICATION TO SPACE VEHICLES

In making a general survey of switches which are available, two steps were taken: first, a general letter was written to various manufacturers requesting information on their line of switches; and second, a more detailed letter was sent to the manufacturers who requested more information as to what was desired. Copies of the letters utilized are appended hereto. The first letter was divided into two parts: One was sent to manufacturers of pressure actuated switches and the other was sent to manufacturers of rotary switches. It was felt that perhaps a rotary switch might have application to the work of the project.

Lists of the manufacturers contacted through both the pressure actuated and rotary switch letters follow the example letters. A copy of the more detailed letter together with a typical reply is also included. Copies of the brochures obtained under this survey have been catalogued and turned over to Mr. Melton for further use by the Propulsion and Vehicle Engineering Laboratory.

Patents were examined for the past five years and while a few at first appeared to be applicable to the project, it was soon apparent that none were of any particular value. What patents which were abstracted have been turned over to Mr. Melton.

June 22, 1964

Gentlemen:

We are studying an application which requires a pressure actuated switch capable of acting under unusually severe mechanical conditions. Would you send us a description or brochure on your line of this type switch.

We will appreciate any information you can provide.

Very truly yours,

L. W. Ross  
Head  
Technical Information Section

LWR:wl

## MAILING LIST FOR PRESSURE ACTUATED SWITCH

Aerodyne Controls Corp.  
90 Gazza Blvd.  
Farmingdale, New York

Aeroflex Laboratories, Inc.  
48-25 36th Street  
Long Island City, New York

Aero Instrument Facility  
11975 Sherman Way  
North Hollywood, California

Aero Mechanism, Inc.  
7750 Burnet Avenue  
Van Nuys, California

Aerotex Industries, Inc.  
Pemberwick Road  
Greenwich, Connecticut

Allen-Bradley Company  
138 West Greenfield Avenue  
Milwaukee 4, Wisconsin

Avnet Electronics Corp.  
70 State Street  
Westbury, New York

Bendix Corporation  
Montrose Division  
South Montrose, Penn.

Bristol Company  
Box 1790 EBG  
Waterbury 20, Conn.

Captive Seal Corporation  
121 Clinton Road  
Caldwell, New Jersey

Carleton Controls Corporation  
P. O. Box 68  
East Aurora, New York

Caruthers and Fernandez Mfg. Corp.  
1501 Colorado Avenue  
Santa Monica, California

Century Electronics & Instruments, Inc.  
6550 East Apache Street  
Tulsa, Oklahoma

Colvin Laboratories, Inc.  
364 Glenwood Avenue  
East Orange, New Jersey

Computer Instruments Corp.  
92 Madison Avenue  
Hempstead, New York

Consolidated Controls Corp.  
6 Durant Avenue  
Bethel, Connecticut

Controls Company of America  
Control Switch Division  
1420 Delmar Drive  
Folcroft, Penn.

Controls Company of America  
9555 Soreng Avenue  
Schiller Park, Illinois

Cook Electric Company  
6401 West Oakton Street  
Morton Grove, Illinois

Cook Electric Company  
2700 Southport Avenue  
Chicago 14, Illinois

Cutler-Hammer, Inc.  
321 North 12th Street  
Milwaukee, Wisconsin

Datametrics, Inc.  
87 Beaver Street  
Waltham, Massachusetts

Dietz Company, Inc.  
14-26 28th Avenue  
LIC 2, New York 11102

Dynamic Controls Corp.  
8 Nutmeg Road  
South Windsor, Connecticut

MAILING LIST FOR PRESSURE ACTUATED SWITCHES (Cont.)

Edcliff Instruments  
1711 South Mountain Avenue  
Monrovia, California

Electrospace Corporation  
12 Morris Avenue  
Glen Cove, New York

Essex Manufacturing Co., Inc.  
8213 Gravois  
Saint Louis, Missouri

Fairchild Controls Corp.  
225 Park Avenue  
Hicksville, New York

Fasco Industries, Inc.  
255 North Union Street  
Rochester 2, New York

Fisher and Porter Company  
115 Warminster Road  
Warminster, Pennsylvania

Franson Products  
894 Production Place  
Newport Beach, Calif.

Frebank Company  
Box 70  
Glendale 5, California

The Fredericks Company  
Anne Street  
Bethayres, Pennsylvania

Furnas Electric Company  
1197 McKee Street  
Saint Batavia, Illinois

General Controls Company  
801 Allen Avenue  
Glendale 1, California

General Controls Company  
Automation Controls Division  
2000 South Wolf Road  
Des Plaines, Illinois

General Electric Company  
Industrial Sales Operation  
Section 998-75  
Schenectady, New York

Glassco Instrument Company  
777 South Arroyo Parkway  
Pasadena, California

Giannini Controls Corporation  
1600 South Mountain Avenue  
Duarte 1, California

B. F. Goodrich Company  
Aerospace and Defense Products Div.  
500 South Main Street  
Akron, Ohio

Gorn Electric Co., Inc.  
843 Main Street  
Stamford, Connecticut

Hagan Chemicals & Controls, Inc.  
Hagan Center  
Pittsburgh, Pennsylvania

Haydon Switch, Inc.  
536 South Leonard Street  
Waterbury 20, Connecticut

Hoke, Inc.  
1 Tenakill Park  
Cresskill, New Jersey

Honeywell  
Apparatus Controls Division  
2755 Fourth Avenue, S.  
Minneapolis, Minnesota

Hydra-Electric Company  
3151 Kenwood Street  
Burbank, California

IMC Magnetism Corporation  
Arizona Division  
1900 East 5th Street  
Tempe, Arizona

MAILING LIST FOR PRESSURE ACTUATED SWITCHES (Cont.)

Instruments, Inc.  
3102 Charles Page Blvd.  
Tulsa, Oklahoma

Kidde Aero-Space Division  
477 Main Street  
Belleville 9, New Jersey

Kollsman Instrument Corp.  
80 45th Avenue  
Elmhurst 73, New York

Lear-Siegler, Inc.  
Power Equipment Division  
17622 Broadway  
Cleveland 1, Ohio

Londex, Ltd.  
Anerley Works  
207 Anerley Road  
London, S. E. 20.  
England

Meletron Corporation  
P. O. Box 38546  
Los Angeles, California

The Mercoid Corporation  
4201 Belmont Avenue  
Chicago, Illinois

Metals and Controls, Inc.  
Corporation Division of  
Texas Instruments, Inc.  
Forest Street  
Attleboro, Massachusetts

Miller-Robinson Company  
7007 Avalon Blvd.  
Los Angeles 3, California

Newark Controls Company  
15 Ward Street  
Bloomfield, New Jersey

Pall Corporation  
30 Sea Cliff Avenue  
Glen Cove, New York

Photocon Research Products  
421 North Altadena Drive  
Pasadena, California

Ripley Company, Inc.  
1 Factory Street  
Middletown, Connecticut

Robertshaw-Fulton Controls Co.  
Fulton Sylphon Division  
Knoxville, Tennessee

Rucker Company  
4700 San Pablo Avenue  
Oakland 8, California

Saturn Electronic Corporation  
145 Mitchael Drive  
Syosset, New York

Scaico Controls, Inc.  
220 Taylor Street  
Riverside, New Jersey

Servomechanisms, Inc.  
200 North Aviation Blvd.  
El Segundo, California

Servonic Instruments, Inc.  
1644 Whittier Avenue  
Coasta Mesa, California

Sirco Products, Inc.  
2706 3rd Avenue  
Seattle, Washington

H. E. Sostman and Co.  
347 East Lincoln Avenue  
Box 60  
Cranford, New Jersey

Southwestern Industries, Inc.  
5880 Centinela Avenue  
Los Angeles, California

Speidel Corporation  
Industrial Division  
Speidel Industrial Park  
Warwick, R. I.

MAILING LIST FOR PRESSURE ACTUATED SWITCHES (Cont.)

Square D Company  
4041 North Richards  
Milwaukee, Wisconsin

Statham Instruments, Inc.  
12401 West Olympic Blvd.  
Los Angeles, California

Sun Electric Company  
6323 Avondale  
Chicago, Illinois

Superior Mfg. and Instrument Corp.  
36-07 20th Avenue  
Long Island City, New York

Switchmaster Corporation  
Electronic Center  
Mt. Carmel, Illinois

Trans-Sonics, Inc.  
Box 328  
Lexington 73, Massachusetts

Unidynamics  
Universal Match Corporation  
472 Paul Avenue  
Saint Louis 35, Missouri

United Electric Controls Company  
85 A School Street  
Watertown, Massachusetts

Wiancko Engineering Company  
255 North Halstead  
Pasadena, California

June 29, 1964

Gentlemen:

We are studying an application which requires a rotary switch capable of acting under unusually severe mechanical conditions. Would you send us a description or brochure on your line of this type switch.

We will appreciate any information you can provide.

Very truly yours,

L. W. Ross, Head  
Technical Information Section

LWR:w1

July 6, 1964

Gentlemen:

We are studying an application which requires a rotary switch capable of acting under unusually severe mechanical conditions. Would you send us a description or brochure on your line of this type switch.

We will appreciate any information you can provide.

Very truly yours,

L. W. Ross, Head  
Technical Information Section

LWR:wl



## MAILING LIST FOR ROTARY INFORMATION

Accuracy Raytron Electronics, Inc.  
Box 538  
Cheimsford, Massachusetts

Aerovox Corporation  
Hi-Q Division  
Seneca Avenue  
Box 493  
Olean, New York

Airflyte Electronics Company  
537 Avenue A  
Bayonne, New Jersey

Aico Electronic Products, Inc.  
3 Wolcott Avenue  
Lawrence, Massachusetts

Allis-Chalmers Manufacturing Co.  
935 South 70th Street  
Box 512  
Milwaukee, Wisconsin

American Solenoid Company, Inc.  
245 East Inman Avenue  
Rahway, New Jersey

Arnhold Ceramics, Inc.  
1 East 57th Street  
New York, New York

Arrow Hart and Hegeman Electronics Co.  
103 Hawthorne Street  
Hartford, Connecticut

Automatic Electric Sales Corp.  
Northlake, Illinois

Barker Sales Company  
339 South Broad Avenue  
Ridgefield, New Jersey

Birnbach Radio Company, Inc.  
145 Hudson Street  
New York, New York

Bolton Electronics Corp.  
153 East Main Street  
Smithtown, New York

A. F. Bulgin and Co., Ltd.  
By-Pass Road  
Barking, Essex  
England

Carling Electric, Inc.  
505 New Park Avenue  
West Hartford, Connecticut

Carson Manufacturing Co., Inc.  
2426 East 55th Street  
Indianapolis, Indiana

Centralab  
Electronics Division of Globe-Uniin, Inc.  
900 934 East Keefe Avenue  
Milwaukee, Wisconsin

Chicago Dynamic Industries, Inc.  
1725 West Diversey  
Chicago, Illinois

Chicago Switch Division  
1733 Milwaukee Avenue  
Chicago, Illinois

Chicago Telephone of California, Inc.  
1010 Sycamore Avenue  
South Pasadena, California

Cole Electric Company  
8439 Steller Drive  
Culver City, California

Collectron Corporation  
304 East 45th Street  
New York, New York

CTS Corporation  
1142 West Beardsley Avenue  
Elkhart, Indiana

Culver-Stearns Mfg. Co.  
354 Franklin Street  
Worcester, Massachusetts

Couch Ordnance, Inc.  
3 Arlington Street  
North Quincy, Massachusetts

## MAILING LIST FOR ROTARY INFORMATION

Daven Division  
General Mills, Inc.  
530 West Mt. Pleasant Ave.  
Livingston, New Jersey

The Digitran Company  
855 South Arrow Parkway  
Pasadena, California

Disc Instruments, Inc.  
3014B South Halladay Street  
Santa Ana, California

Eagle Electric Mfg. Co., Inc.  
23-10 Bridge Plaza S.  
Long Island City, New York

Eagle Signal Company  
202 20th Street  
Moline, Illinois

The Ealing Corporation  
Cambridge, Massachusetts

Eastern Speciality Company  
3619 North Eight Street  
Philadelphia, Pennsylvania

Electro Development Company  
14701 Keswick Street  
Van Nuys, California

Electro-Mec Instrument Corp.  
47-51 33rd Street  
Long Island City, New York

Electro-Miniatures Corporation  
626 Huyler Street, S.  
Hackensack, New Jersey

Electro Switch Corporation  
167 King Avenue  
Weymouth, Massachusetts

Electro Switch Corporation  
Slip Ring Division  
Main Street  
Osterville, Massachusetts

Farmer Electric Products Co., Inc.  
Tech Circle  
Natick, Massachusetts

Gamewell Company  
Electronics Division  
1688 Chestnut Street  
Newton Upper Falls, Mass.

General Automation Corporation  
121 Centre Avenue  
Secaucus, New Jersey

General Devices, Inc.  
P. O. Box 253  
Princeton, New Jersey

General Electric Company  
Wiring Device Department  
95 Hathaway Street  
Providence, R. I.

General Precision Aerospace  
1150 McBride Avenue  
Little Falls, New Jersey

General Time Corporation  
Electronics Systems Division  
201 Summer Street  
Stamford, Connecticut

Graphite Metallizing Corporation  
1036 Nepperhan Avenue  
Yonkers, New York

Grayhill, Inc.  
569 Hillgrove Avenue  
La Grang, Illinois

The Gribbsby Company  
407 North Salem Avenue  
Arlington Heights, Illinois

Hart Manufacturing Company  
110 Bartholomew Avenue  
Hartford, Connecticut

## MAILING LIST FOR ROTARY INFORMATION

Hathaway Instruments, Inc.  
5800 East Jewell Avenue  
Denver, Colorado

Honeywell Micro Switch Division  
Chicago and Spring Street  
Freeport, Illinois

Honeywell Military Products Group  
2753 Fourth Avenue S.  
Minneapolis, Minnesota

Hurletron, Inc.  
135 La Salle Street  
Chicago, Illinois

Industrial Devices, Inc.  
Edgewater, New Jersey

ITT Kellogg  
6650 South Cicero Avenue  
Chicago, Illinois

Indak Manufacturing Corp.  
1915 Techny Road  
Northbrook, Illinois

Instrument Development Labs., Inc.  
67 Mechanic Street  
Attleboro, Massachusetts

Janco Corporation  
3111 Winona Avenue  
Burbank, California

Javex Electronics  
P. O. Box 646  
Redlands, California

J-B-L Instrument Company  
Sycamore and Mill Roads  
Clifton Heights, Pennsylvania

J-B-T Instruments, Inc.  
133 Hamilton Street  
New Haven, Connecticut

Kahlenberg Brothers Company  
Box 358  
Two Rivers, Wisconsin

Kalpa Scientific Laboratories  
P. O. Box 172  
Flemington, New Jersey

Langevin  
Division of Sonotec, Inc.  
503 South Grand Avenue  
Santa Ana, California

Ledex, Inc.  
123 Webster Street  
Dayton, Ohio

Leviton Manufacturing Co., Inc.  
236 Greenpoint Avenue  
Brooklyn 72, New York

Lewis Engineering Company  
339 Church Street  
Naugatuck, Connecticut

Lind Instruments, Inc.  
2294 Mora Drive  
Mountain View, California

Mallory Controls Company  
Division of P. R. Mallory & Co.  
Box 231  
Frankfort, Indiana

Markite Corporation  
155 Waverly Place  
New York, New York

Mason Electric Corporation  
3839 Verdugo Road  
Los Angeles, California

Micro-Lectric, Inc.  
19 Debevoise Avenue  
Roosevelt, New York

Microwave Associates, Inc.  
Northwest Industrial Park  
Burlington, Massachusetts

Milli-Switch Corporation  
P. O. Box 67  
Gladwyne, Pennsylvania

## MAILING LIST FOR ROTARY INFORMATION

Murihead Instruments, Inc.  
1101 Bristol Road  
Mountainside, New Jersey

New England Instrument Co.  
H. F. Brown Way  
Natick, Massachusetts

The J. M. Ney Company  
Maplewood Avenue  
Bloomfield, Connecticut

Oak Manufacturing Co.  
Crystal Lake, Illinois

Ohmite Manufacturing Co.  
3635 Howard Street  
Skokie, Illinois

Pacific Scientific Company  
Aerosapce Division  
P. O. Box 22019  
Los Angeles, California

Painton, Inc.  
116 Kraft Avenue  
Bronxville, New York

Pepco, Inc.  
2080 Placentia  
Costa Mesa, California

Philmore Manufacturing Co., Inc.  
130 01 Jamaica Avenue  
Richmond Hill, New York

Pitometer Log Corporation  
202 East 44th Street  
New York, New York

Pobog Industries, Inc.  
117-119 North Lindley Avenue  
Whittier, California

Joseph Pollak Corporation  
85 Freeport Street  
Boston, Massachusetts

Poly Scientific Corporation  
Route 460, N.  
Blacksburg, Virginia

Precision Line, Inc.  
63 Main Street  
Maynard, Massachusetts

Precision Specialities, Inc.  
Box 118  
Pitman, New Jersey

Quantic Industries  
Pelmec Division  
1011 Commercial Street  
San Carlos, California

Radio Components, Ltd.  
50 Wingold Avenue  
Toronto 19, Canada

Rawco Instruments, Inc.  
P. O. Box 7393  
Fort Worth, Texas

R. C. L. Electronics, Inc.  
Hixon Place  
Maplewood, New Jersey 07040

The Milton Ross Company  
514 Second Street Pike  
Southampton, Pennsylvania

Rotary Devices Corporation  
37 Jay Street  
Englewood, New Jersey

Rye Sound Corporation  
145 Elm Street  
Mamaroneck, New York

Schrack Electrical Sales Corp.  
1140 Broadway  
New York, New York 10001

Sealectro Corporation  
139 Hoyt Street  
Mamaroneck, New York

Seacor, Inc.  
Box 134  
Fleetwood Station  
Mount Vernon, New York

## MAILING LIST FOR ROTARY INFORMATION

Shallcross Manufacturing Co.  
Preston Street  
Selma, North Carolina

Sigma Instruments, Inc.  
70 Pearl Street  
South Braintree, Massachusetts

Slip Ring Company of America  
3612 West Jefferson Blvd.  
Los Angeles, California

Herman H. Smith, Inc.  
2326 Nostrand Avenue  
Brooklyn, New York

Specialties Manufacturing Company  
8821 Fenkell  
Detroit, Michigan

Stackpole Carbon Company  
Electro-Mechanical Products Division  
Johnsonburg, Pennsylvania

Staco, Inc.  
1139 Baker Street  
Costa Mesa, California

Staco, Inc.  
Standard Electrical Products Div.  
2240 East Third Street  
Dayton, Ohio

Subminiature Instruments Corp.  
3236 Kansas Avenue  
Riverside, California

Sunshine Scientific Instruments  
1810 Grant Avenue  
Philadelphia, Pennsylvania

Superior Switch Company  
1001 West Broad Street  
Richmond, Virginia

Switchcraft, Inc.  
5555 North Elston Avenue  
Chicago, Illinois

Tech Laboratories  
Bergen and Edsall Blvds.  
Palisades Park, New Jersey

Teledyne Precision, Inc.  
3155 West El Segundo Blvd.  
Hawthorne, California

Thermo Electric Company, Inc.  
109 Fifth Street  
Saddle Brook, New Jersey

TIC Division  
Bowmar Instrument Corp.  
531 Main Street  
Acton, Massachusetts

Tower Manufacturing Corp.  
158 Pine Street  
Providence, R. I.

Ucinite Company  
Division of United Carr Fastener  
459 Watertown Street  
Newtonville, Massachusetts

Unison Electronics Corp.  
1634 Marion Street  
Grand Haven, Michigan

Universal Circuit Controls Corp.  
3610 Oakton Street  
Stokie, Illinois

Vemaline Products Company  
Department EEM  
511 Commerce Street  
Franklin Lakes, New Jersey

Westinghouse Electric Corp.  
Electronic Components Specialty  
Products Group  
Research and Development Center  
Pittsburg, Pennsylvania

Winslow Electronics, Inc.  
1000 First Avenue  
Asbury Park, New Jersey

TYPICAL REPLY  
AND  
SAMPLE OF MORE  
DETAILED INQUIRY

July 20, 1964

Instrument Development Laboratories, Inc.  
67 Mechanic Street  
Attleboro, Massachusetts 02703

Gentlemen:

Thank you for your information sent in your letter of July 13. We are interested in knowing the possible recommendations your engineering department might make on a pressure actuated switch with the following specifications:

1. Temperature range - 200<sup>0</sup>F to + 200<sup>0</sup>F
2. Operational stability under environments of 100G vibrations at 10 - 2000 cps
3. Actuation change in pressure of one (1) PSI
4. Electrical current 3 amps at 28 volts DC
5. Positive "on or off" toggle principle

We will appreciate any further information you can provide.

Very truly yours,

L. W. Ross, Head  
Technical Information Section

LWR/ym



# INQUIRY SHEET FOR PRESSURE SWITCH

CORPORATION • 121 CLINTON ROAD, CALDWELL, NEW JERSEY  
CAPITOL 8-0243

REFER TO:

NAME DESCRIPTION: PRESSURE ACTUATED SWITCH

## SPECIFIC FUNCTION:

TYPE: SPST ☐; SPDT ☐; DPST ☐; DPDT ☐; DUAL ☐; OTHER ☐  
Gage ☐; Differential ☐

## PERFORMANCE DATA:

Electrical: Voltage, AC ☐; DC ☒; 28 Volts max; Cps:             
Current: (Max) 3 amps inductive;            amps. resistive  
Overload:            amps for            cycles max.  
Switch circuit resistance:            ohms max.  
Contact Life:            cycles min; Hipot:             
Other circuit components integrally encapsulated (resistors, relays, diodes, etc.)

Fluid: Primary:            Secondary (test):           

Pressures: Trip point (rising pressure): 65 psig +           

Reset point (decreasing pressure): 64 psig +           

Proof:            psig; Burst:            psig min

Differential:            psig +           ; One Way ☐; Both Ways ☐

Environment: Temp. Operating: -200°F to +200°F; Exposure:           

Max. Vibration: 2000 CPS

Shock: 100 G's Acoustic Noise:           

Endurance:            Altitude:           

## PHYSICAL DATA:

Port Size & Type:           ; Mount on pressure connection?           

Other Mounting provisions:           

Electric Connections: Receptacle:            (size & No. of pins)

Lead wires:            (size, length & no.)

Terminals:            (describe)

## SPECIAL CONDITIONS: (Describe)

Switch is to be actuated when a change of 1 Psi occurs

REFERENCE: Company: Georgia Inst. of Tech.

Engineer/Buyer: L.W. Ross

Submitted by:            " " Date: 7-9-65



July 9, 1964

Captive Seal Corporation  
121 Clinton Road  
Caldwell, New Jersey

Gentlemen:

Thank you for the information you sent us in your letter of June 25/CL-3499. We are returning your inquiry sheet describing some of the more important features desired in a pressure actuated switch.

We will appreciate any further information you can provide.

Very truly yours,

L. W. Ross, Head  
Technical Information Section

LWR:gh

Enclosure:

INSTRUMENT DEVELOPMENT LABORATORIES

67 MECHANIC STREET  
ATTLEBORO, MASSACHUSETTS 02703

*Division of Hollmorgen Corporation*

AREA CODE 617  
222-3880

July 24, 1964

JUL 27 1964

Mr. L. W. Ross, Head  
Technical Information Section  
Georgia Institute of Technology  
Engineering Experiment Station  
Atlanta, Georgia 30332

Dear Mr. Ross:

Thank you for your July 20 letter. Your requirements for a pressure actuated switch have been reviewed. We regret that no items of our manufacture meet or come close to meeting your requirements.

As outlined with the literature enclosed with our July 13 letter, all of our switch products are continuous rotation rotary switches which accept low-level or high-level electrical signals from a number of transducers. The output of the switch are the same electrical signals presented sequentially, one at a time. These high performance switches cause a minimum of degradation of the electrical signals and they are designed to withstand the severe environment of airborne applications.

From the description of your requirements, however, we see no possibility where our switch products would apply in this instance.

Sincerely,

INSTRUMENT DEVELOPMENT LABORATORIES

E. T. CONNOR  
Executive Vice President

ETC:jz

cc: Mr. William Hunter  
ECRA Inc.  
408 Clinton Avenue  
Huntsville, Alabama



CORPORATION • 121 CLINTON ROAD, CALDWELL, NEW JERSEY

07007

TEL: AREA CODE 201 228-0243

TWX: AREA CODE 201 226-5524

JUL 31 1964

IN REPLY REFER TO:

July 28, 1964/CL-3585

Georgia Institute of Technology,  
Engineering Experiment Station,  
Atlanta, Georgia 30332,

Attention: Mr. L. W. Ross, Head,  
Technical Information Section,

Gentlemen:

At the present time we have no stock design which would meet your requirements. Currently available parts are limited to -80°F as the lowest temperature and at 65 Psig, would have an on/off differential of approximately 4 Psig.

If we may be of any further help please contact us immediately.

Very truly yours,

CAPTIVE SEAL CORPORATION

R. L. DOUG,  
General Manager.

RPD/rf